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A Temperature Control Index in Dairy Stable Standardization[1]

By J. L. Strahan[2]

IN DEVELOPING dairy stable standards three important considerations involved are (1) the physical environment of the cow, (2) the economics of milk production, and (3) the quality of the product. The standards now usually accepted have been developed with the principal object of preventing contamination of milk. They are essentially regulatory in nature and subject to enforcement by governmental agencies as a means of social protection. Inasmuch as the cow is the prime producer and the dairyman must remain in business if the public is to be supplied with milk, it would seem that logical standards should be based upon (1) the requirements of the cow, (2) the possibility for profitable production, and (3) a sanitary product. Believing that these three essentials are not mutually antagonistic, I have made them the basis of the recommendations in this paper.

For a number of years past, and at present, the largest part of our milk supply has come from comparatively small herds housed in the conventional manner, namely in 2-row barns, each cow occupying a single stall. Small producers will continue for some time to come to find this the most economical housing program, although larger producers are experimenting with other methods involving group housing and special milking stables. It is for the small producers, or others who will continue to use the conventional methods, that these standards are primarily intended.

Standards that will adequately cover the dairy stable naturally fall into two groups: (1) Those having to do with unit space requirements, and (2) those having to do with construction and the use of materials. The first group to some extent affects the comfort and health of the cow, but it is more largely concerned with arrangement for convenience and economy of production. The second group is almost entirely concerned with the maintenance of an environment conducive to maximum biological efficiency. Its provisions will affect the cow as a prime producer. Hence it is suggested as the first to be considered.

THE PROBLEM

It has long been recognized that there is a definite relation between climate and construction requirements. In general, warmer construction is required in the North than in the South. The question to be answered by standards is, "How warm must the construction be for any given set of conditions?" The factors entering into a definite and precise determination are all well enough known to warrant a tentative statement that can be taken as a guide to design. It remains to develop a statement correlating these factors into acceptable standards of materials use.

Temperature control infers the presence of heat, the possibility for reducing losses to a minimum, and the effective utilization of the balance. It must be assumed in designing a building that a ventilating system will be provided that will exercise a practical degree of control over the loss of heat through air change. It remains, therefore, to manipulate the conduction and radiation factors, namely, area of exposure and insulation, in such a way as to strike an economic balance between cost of construction and the practical necessities imposed by climate and available materials. It would seem more logical to develop design control standards that involve area of exposure and heat transmission rather than, as has been customary in the past, to consider "volume per cow" as a criterion.

The concept of "heat balance" provides a means for doing this in a manner sufficiently precise to meet the requirements of the designer. It has been expressed[3] in terms of animal units as follows:

$$H = \frac{VD}{53} + ACD \qquad [1]$$

in which

H = heat available (Btu) per cow per hour
V = cubic feet air change per cow per hour
D = temperature difference in degrees (Fahrenheit)
A = area of exposure per cow in square feet
C = weighted average transmission coefficient.

The quantity ($VD \div 53$) represents heat loss by air change, and ACD represents heat loss by conduction and radiation.

The quantity AC is the loss of heat per cow per hour per degree of temperature difference by radiation, and is very definitely a function of the design of the stable and the materials from which it is built. A wide, high stable, with few stock in it will have a large value for A. A small, low one, filled to capacity with animals, will have a low value for A. The value for C can be controlled by designing walls, windows, doors, and ceiling to have a greater or less resistance to heat flow as the requirements demand. Thus the value AC states the design characteristics of the stable in terms of unit heat loss. It can therefore be considered an index of the possibility for temperature control. I am proposing that this index be standardized for use as a guide to design. I suggest it be designated by the term "temperature control index."

The relation between all the factors affecting the value of the temperature control index can be stated by a simple transformation of the heat balance formula, thus

$$H = \frac{VD}{53} + ACD$$

$$AC = \frac{H}{D} - \frac{V}{53} \qquad [2]$$

A standard value for AC infers assumed average values for these several factors, H, D, and V. Objections might be raised to the practicability of standardizing such a highly variable factor as climate. It must be admitted that,

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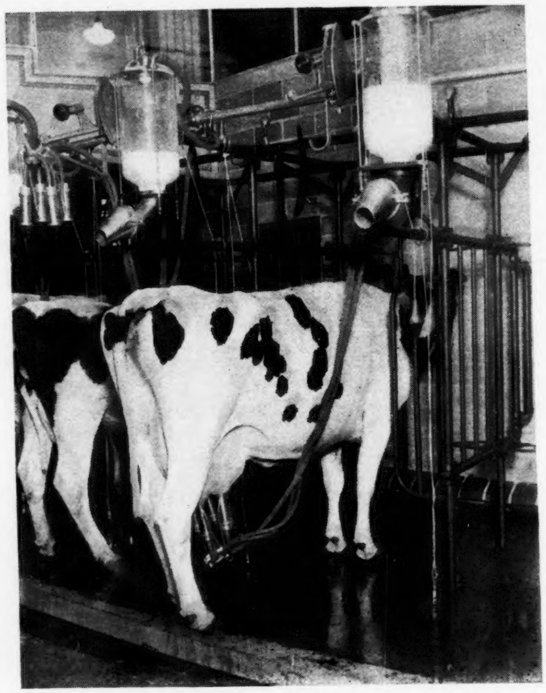
[1]A paper (abridged) presented on the program of the Structures Division at the 26th annual meeting of the American Society of Agricultural Engineers, at Ohio State University, Columbus, June 1932.

[2]Consulting agricultural engineer. Mem A S A E.

[3]Electric Ventilation of Dairy Stables. Strahan and Marsh. AGRICULTURAL ENGINEERING, vol 11, No 4, p 4 (1930).

inasmuch as we are after a criterion that can govern the design of a structure which, when once finished, is in no degree variable, we must accept certain average conditions for the factors affecting the design, and call them, for the purposes of the case, "standard". It is further to be observed that, although climate as expressed by D is highly variable, the factor V, by a proper design of the ventilating system, can be made to vary inversely in such a way that the product of the two can be considered reasonably constant.

Armsby and Kriss at the institute of animal nutrition have shown that heat production by dairy cows is variable, depending upon size and condition of lactation, or more properly, plane of nutrition. A small cow in low milk flow will average 2700 Btu per hour, while a large animal in heavy milk flow may produce up to 3700 Btu. This is not all available for warming air, as approximately 25 per cent of it is in the form of latent heat. During cold periods some moisture is usually condensed and some of the latent heat is liberated and made available. Clyde[4] has pointed out that other sources of heat contribute to the control of stable temperature during cold snaps, namely heat stored up in the structural materials, and heat from the soil under the stable floor when the stable temperature falls below ground temperature. In addition, some heat is contributed by the direct rays of the sun striking roof and walls in bright, cold weather.



As Mr. Strahan points out, "in developing dairy stable standards three important considerations involved are (1) the physical environment of the cow, (2) the economics of milk production, and (3) the quality of the product"

Taking all these factors into consideration, it is reasonable, I believe, to estimate the value for H for the purpose of stable and ventilation design to be 3,000 Btu per cow per hour. This value squares with the observed results in numerous cases and we therefore propose it as a tentative standard, pending the results of further research along these lines.

CLIMATE

The factor D, or climate, involves outside and inside temperature. Let us consider outside temperature first.

Kelley[5] has presented a map of the United States divided into four climatic zones, based upon U S Weather Bureau data, involving average temperatures for the months of January and February over a period of thirty years at one hundred selected stations. Zone 1 is the coldest and most northerly. Zone 2 adjoins Zone 1 on the south; Zone 3 adjoins Zone 2 on the south, and Zone 4 is the most southerly and warmest. The three northern zones are those in which housing may be said to play an important part in environmental control in the winter time, and present proposals are limited to them.

It has been found impractical to attempt to provide a building that will conserve natural heat sufficiently to maintain comfortable barn temperatures without restricting ventilation in the northern zones during periods when outside temperatures are extreme. However, such extremes are of comparatively short duration, and can usually be met for short periods without danger to the stock by restricting ventilation and by permitting inside barn temperatures to approach close to freezing. Average climatic conditions can be met by a proper coordination of construction and ventilation design. Daily mean minimum temperature during January and February is, in Zone 1, 5 degrees; in Zone 2, 17 degrees, and in Zone 3, 27 degrees.

I am suggesting that these temperatures be established as standard values to be used in controlling the design of buildings to house dairy cows, except that the value for Zone 2 be reduced from 17 to 16 degrees for reasons that will appear later, with the understanding that the ventilating system be designed to function normally when they obtain and so constructed that ventilation may be restricted at lower outside temperatures and increased at higher.

The factor of inside stable temperature must be considered in three phases from the standpoint of stable design, namely, the optimum or most desirable temperature, the lowest permissible temperature, and the temperature that is possible of attainment under conditions imposed by climate and economy of construction.

What is the most desirable inside temperature for the dairy stable? Before this question can be definitely answered we need more research data on the physiological reactions of the cow to temperature variations. Kelley intimates that his recent studies in Wisconsin will place the comfort zone for dairy cows under winter stabling conditions between the extremes of 45 and 60 deg. He has previously suggested[6] that a temperature between 45 and 50 deg would be satisfactory in cold climates.

This question was included in a questionnaire circulated in 1929 by the Structures Division of the Society to 6000 practical dairymen throughout the country, of whom about ten per cent returned complete statistics. From Zones 1 and 2, 280 replies were received on this point from a group of men nearly 70 per cent of whom had handled cows for over ten years. Of these, 91 favored temperatures between 40 and 50 deg, and 101 preferred temperatures between 50 and 60 deg. Of the latter (high temperature) group more were located in Zone 2, while of the former (low temperature) group, the majority were located in Zone 1. From the foregoing it seems safe to place the optimum temperature somewhere between 40 and 60 deg in Zones 1 and 2.

From Zones 3 and 4, 66 replies were received, one-half of which indicated a temperature preference between 60 and 70 deg, and 35 per cent between 50 and 60 deg. The general trend is toward higher temperatures, averaging just about ten degrees higher than in Zones 1 and 2. It may be that the comfort zone for the cow varies with the conditions to which she becomes acclimated, or it may be that southern dairymen are satisfied to accept higher temperatures because they cannot help themselves. Whatever the reason, it will undoubtedly be desirable to accept a

[4] Control of Temperature and Humidity in Dairy Stables. A W Clyde. Report of graduate study and Experiment Station Project 28. Iowa State College 1929-30.

[5] Ventilation of Farm Barns. M A R Kelley. Technical Bulletin No 187, U S D A 1930.

[6] Principles of Dairy Barn Ventilation. M A R Kelley. Farmers' Bulletin 1393, U S D A 1924.

higher value for a standard stable temperature in Zone 3 than in Zones 1 and 2.

How low may the temperatures be permitted to go before there is danger either to the stock, to the building and equipment, or the rate of production of milk?

Gradual temperature changes, such as might occur in a tightly built stable with good ventilation, are not considered particularly harmful, and therein lies the value of good insulation. Sudden changes, accompanied by draft and highly variable humidity conditions, are conducive to pneumonia, particularly in the case of young animals. Where a water system is installed, temperatures at or near freezing are to be avoided. In uninsulated buildings quick temperature changes, or continual low temperatures, result in condensation of moisture on wall surfaces that causes rapid deterioration of the materials.

Exactly what range of temperature variation and what rate of change is seriously reflected in the milk pail is at present undetermined. Considerable evidence is available, however, that there is an effect that can be economically avoided by good construction. Consideration of this point was included in the questionnaire project mentioned above. The following specific cases are reported: From Charlotte, N. C., comes a report of a loss of 10 gal per day from a herd of 60 Jerseys during a cold spell. A herd of 26 Guernsey cows in Pennsylvania loses 2 lb per day per cow. Another herd of 89 Holsteins and Guernseys at Rockford, Ill., is reported to drop from 1 to 3 lb per cow per milking, or from 2 to 6 lb per cow per day. From Eldora, Ill., a report from a herd of 22 Jerseys indicates a loss of from 10 to 20 per cent. At Junction City, Kansas, a herd of 40 Holsteins averaging 10,352 lb per year has in it individuals normally producing 90 lb per day that dropped to 50. Brookhill Farm at Genesee Depot, Wis., milking from 600 to 700 cows, reports a daily loss of 5 per cent when the weather suddenly turns cold.

The question concerning minimum permissible temperature was answered by 277 individuals from Zones 1 and 2. Of these only 13.6 per cent felt that temperatures below freezing were permissible. Temperatures between freezing and 35 deg were tolerable to 22.6 per cent, but 50.7 per cent wished to hold the minimum temperature between 35 and 40 deg. Only 13.1 per cent of the total number answering were unwilling to go below 40 deg, and of these somewhat over half were unwilling to go below 50 deg.

Temperatures between 40 and 60 deg for normal winter conditions, and above freezing at all times, seem to be rather generally preferred. Is it possible in practice to produce these conditions?

Clyde[4] working in the stable at Iowa State College, equipped with fan ventilation during the winter of 1929-30, demonstrated that temperatures may be controlled within these limits by regulating air flow, providing heat loss by radiation is reduced to a practical minimum. It is common knowledge among those who have engineered ventilation systems and tested stables that, given protection against wind leakage, temperatures between 40 and 60 can easily be maintained by manipulating the ventilating system in accordance with outside temperature variations, and, further, that in spite of a presumably limited supply of heat, periods of extreme cold weather can be withstood without danger of freezing, provided they do not last too long. The amount of heat known to be produced by the animals cannot alone account for the temperatures maintained under conditions when D equals 70 deg, but such conditions seldom obtain, and are usually associated with changing rather than static weather conditions.

In view of these data, opinions, and experiences, I wish to propose the following as standard temperature conditions (expressed in degrees Fahrenheit) for use in design in Zones 1, 2, and 3:

	Outside temperature		Inside temperature		D	
Zone	Average normal	Average extreme	Optimum	Minimum tolerable	Normal	Maximum
1	5	—10	45	38	40	48
2	16	0	50	40	34	40
3	27	10	55	42	28	32

It will be observed that the variations between all values for the three zones are constant. By reducing average normal temperature for Zone 2 from 17 to 16 deg, the difference between it and both Zones 1 and 3 is 11 deg.

By " average normal" is meant that temperature at which optimum barn temperatures should be maintained with normal air flow.

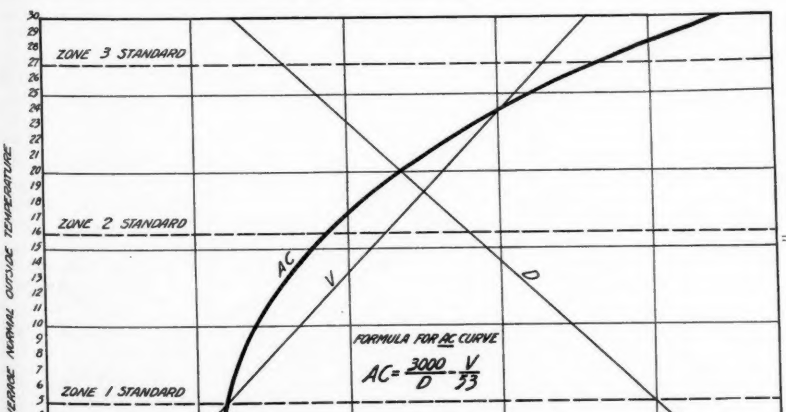
By "average extreme" is meant the lowest temperature that might reasonably be expected to persist for a time long enough to produce a condition of balance between heat production and heat loss in the stable. Lower temperatures are to be expected, but they will not be of such long duration that heat reserves will be unable to cope with them.

By "optimum temperature" is meant that at which cows will produce most efficiently.

By "minimum tolerable" is meant the lowest temperature that will be tolerated in the stable, regardless of either weather or barn conditions.

VENTILATION

The remaining significant factor affecting the value of AC is the rate of air flow per hour per cow. This involves the design of the ventilating system. Although King has stated that a definite rate of air flow, 3545 cfh per cow, should be maintained regardless of temperature variations, in practice it has been found not objectionable to restrict ventilation down to 1500 cfh, or even lower, without serious consequences when necessary to prevent freezing. It



To facilitate the determination of indices between the standards for the three climatic zones of the United States, Mr. Strahan has plotted the standard values for the significant factors in their proper relations, and computed a curve (to the left) which indicates the value for **AC** for any known or assumed value of average outside temperature

is not so much a matter of maintaining a standard of chemical purity as it is of determining the maximum amount of air that can be moved through the stable without seriously interfering with temperature and humidity control. The following observations by Clyde and Kelley bear this out:

Clyde[4] in Zone 2, in a stable with an index of 26.9, maintained a temperature difference of 33 deg, while passing 2100 cfh of air per cow through the stable. At this time he estimated the heat available per cow to be 2780 Btu. In the same stable he maintained a D of 26 deg while passing through 3475 cfh per cow, the heat available being estimated at this time to be only 2400 Btu.

Kelley[5] reports a test in a stable for which I estimate the temperature control index to be approximately 38. Observations indicate the possibility for holding temperature differences as high as 49.1, 52.5, and 55.2 deg while anywhere from three to seven complete changes of air per hour occurred. It is likely that, if the index had been lower, these figures could have been exceeded.

In view of these experiences I am proposing the following values for volume of air flow in the different zones, in cubic feet per hour per cow:

Zone	Normal	Restricted	Theoretical required to prevent condensation
1	2600	2000	2163
2	3175	2600	2225
3	3550	3000	2225

Future tests should be designed with the idea of definitely relating air flow to temperature variations and to temperature-control index.

If the values proposed for the factors which affect the design characteristics of the stable can be accepted as tentative standards, then there remains only to substitute them in the AC formula in order to determine the value of the temperature-control index for each zone.

The formula is

$$AC = \frac{H}{D} - \frac{V}{53}$$

Substituting the values appropriate to Zone 1.

$$AC = \frac{3000}{40} - \frac{2600}{53} = 26$$

A similar substitution for Zones 2 and 3 produces in the first case an index of 29.23, and in the second, 38.28.

There will undoubtedly be locations in Zone 2 that will have climatic characteristics similar to but perhaps not quite so severe as in Zone 1, and where an index somewhat lower than that standardized for Zone 2 will be indicated. In order to facilitate the determination of indices between the standards for the three zones, I have plotted the standard values for the significant factors in their proper relations, and computed a curve which indicates the value for AC for any known or assumed value of average outside temperature. Using average normal temperature for ordinates, and the other factors as abscissas, I have plotted a temperature-difference curve between the extremes of 40 deg and 5 deg outside temperature, and a ventilation curve between the extremes of 2600 cfh per cow at 5 deg outside and 3650 cfh per cow at 27 deg outside temperature. From these two curves was obtained the values of D and V for all outside temperatures from zero to 30 deg and the value for AC computed by substituting them in the formula

$$AC = \frac{H}{D} - \frac{V}{53}$$

Plotting these points produced Curve AC. The broken horizontal lines indicate the data applying to the standardized conditions.

APPLICATION

Consider now the application to design and standardization of structural specifications.

The fact that a stable in Zone 1 has a temperature-control index of 26 means that, if its design calls for an area of exposure, A, of 130 sq ft per cow, then the average heat transmission coefficient must be $(26 \div 130)$, or 0.20 Btu per hour per square foot per degree.

To illustrate the frame construction necessary to meet these conditions, suppose a stable is to be designed to house 30 milking cows and two maternity pens or young stock pens. It will be 74 ft long and 34 ft wide. Its ceiling height will be 8 ft, and it will be provided with 3½ sq ft of glass per cow, making a total of 112 sq ft of glass, the windows to be equipped with storm sash. There will be four doors, each 4 by 7 ft, double thickness, and provided with storm doors for use in cold weather. Headers or other adequate insulation will be specified for the joist ends, and ½-in insulating board, will be used under the joists. The wall studs will be covered outside with ⅞ in siding over ½-in insulating board, and on the inside with ½-in insulating board and ⅝-in matched ceiling. A summary of the insulation characteristics of this building is as follows:

Section	Area, sq ft	Thermal transmittance per unit area, U	Total loss per degree
Ceiling	2409	0.210	505.89
Walls	1401	0.145	203.14
Windows	112	0.500	56.00
Doors	112	0.200	22.40
Foundation	71	0.530	37.60
Totals	4105		825.03

$$A = \frac{4105}{32} = 128.28 \text{ sq ft}$$

$$C = \frac{825.03}{4105} = 0.201$$

$$AC = 128 \times .201 = 25.78$$

Through this building it will be possible to pass at least 2600 cu ft of air per hour per cow without reducing the temperature below 45 deg during normal winter conditions, and it will be possible, by restricting the flow to 2000 cu ft, to maintain the temperature at or above 38 deg in average extreme weather.

This solution is not intended to indicate a standard construction; rather it illustrates the method of applying the proposed index to design control. Any number of different solutions might be reached, and in all likelihood less expensive construction specified. For instance, the ceiling material might be omitted, if the wall insulation is carried up to the floor level above, and if plenty of hay is stored over the stable during cold weather. Other materials might be used in the walls, such as light-weight aggregate concrete units, hollow tile, brick, etc. As to which, each man's problem is a separate one.

Therefore, in submitting these proposals, I would like to emphasize the value of this control index (either the proposed values, or modifications of them, if found necessary in order more closely to meet conditions) as a guide to design and the use of materials. We have aimed heretofore at Standard wall constructions in the various materials, at standard structural details. I submit that the wealth of materials and the almost infinite combinations of them available to the farmers will make any specific structural details for standard wall assemblies impracticable. What might be economical for one may be quite the reverse for another, so that such specific detailed standards would find only a limited acceptance.

Some of the Economic Aspects of an Engineered Agriculture[1]

By M. L. Wilson[2]

AGRICULTURAL engineering and agricultural economics, as they have developed in the United States during the past two decades, have had much in common. They were the last two of the major divisions of the general agricultural field, to emerge. During their recent development both have had to "crowd into" a field more or less occupied by other organized divisions of our colleges and experiment stations. While both have been aggressive, each has had to maintain scientific and working relationships with its broader affiliated fields of engineering and general economics. Their points of view and attitudes of approach are probably more similar, than between each and any one of the other agricultural divisions. Each produces specific problems for the other. Between what agricultural economists term production economics and farm management, and what engineers describe as engineering economics or production control, there is a large twilight zone.

In the past and at the present, many agricultural research and college institutions are, or have been, administered by men who have what the psychologists term the biological and physical science "mind set." This statement is made with no desire to criticise. It has been largely a matter of evolution. Our experiment station directors have administered their research institutions and have builded well. Their outturn of new and useful knowledge concerning the biological and physical world does them great credit. Their service pays "prosperity dividends" on the public funds so invested, both to the farmer and to society as a whole.

But one difficulty with what I have called biologically-minded agricultural administration has been that the interest was largely centered in new facts about chemical reactions and plant and animal life. Here matters stopped, with the addition perhaps of two questionable assumptions: (1) That nothing else is scientific, or at least is not susceptible to the natural science standard of research methodology, and (2) that new knowledge is applicable to agricultural production without changes in technology, engineering, or the habits, customs, or folk-ways of the farmers themselves. In the evolutionary development of things, this criticism no longer applies to many agricultural experiment stations. There is a decided drift among research administrators to direct their staffs towards tackling the problems which arise out of the need for doing farm jobs in the most efficient manner, with the least human effort, and the relation of all to income, to human valuations of wants and desires, and to what we call the general economic system.

BIOLOGICAL AND PHYSICAL ASPECTS

Biological and physical aspects of agriculture, as organized in such divisions as animal husbandry, agronomy, horticulture, etc, connect with its engineering aspects and economic relations. When this view is fully accepted, it will mean great cooperation and interrelation between the three, but especially between engineering and economics.

I suspect that the real radical and disturber of peace in this three-cornered group will be the engineer, because he has the least respect for the habits, customs, and traditions of agriculture. His shibboleth is efficiency in farm production, and the lessening of burdensome human drudgery. This means changing the attitudes of people, their habits, customs, and traditions. And if five thousand years of human history teach us anything, it is that the changing of human habits, customs, and traditions always results in turmoil, which is ofttimes the price of human progress.

The recognition by all—farmers, investigators, and the public—that each line of agricultural production has its engineering and economic phases, will take us a long way toward an engineered agriculture, which I hope will be administered and organized in accordance with high ideals of economic, social, and ethical welfare.

Let me illustrate what I mean by this engineering and economic relationship, by taking a hog-raising enterprise as an example. My reason for selecting this enterprise is that I have frequently heard it said that engineering has to do principally with machinery and mechanization, and consequently the handling of crops, but that it has very little application to animal husbandry. A few years ago the Illinois Agricultural Experiment Station carried out an outstanding piece of biological work dealing with the worm infestation of hogs. It added greatly to knowledge concerning the life history and control of hog parasites, and resulted in the development of a system of sanitation known as the "McLean County system." The control of the parasite by means of this technique so increases the efficiency of the feed consumed, that the farmer who can produce hogs without worms is on a different competitive plane, and consequently has a great advantage over the farmer who cannot. Now the McLean County system did not stop with knowledge of parasites and their control. It brought in the engineering aspect. Large central hog houses were to be done away with. New portable equipment had to be designed; lots and fields rearranged. In other words, the engineer had a problem in designing a new plant.

ENGINEERING-ECONOMIC RELATIONSHIP

But when the engineer had designed the new plant, the farm management man was asked to enter. He was required to study the effect of this system of production on the size and organization of farms. What are the cost elements in this system, and how do these costs compare with the costs of other systems? Does the sanitary system require a new kind of skill which the average farmer does not possess? If so, are the costs sufficiently low that competitive forces will tend to make specialized hog farms? Will the system have any effect on the different zones of hog production? Here was a wave that originated, so to speak, in biological research, spread over into the engineering field in order to get efficient application, and then into the economic field for its price and value appreciation.

The University of Nebraska made an interesting study of the relation of this project to habit, custom, and tradition. It conducted a survey in a township in which an intensive extension program had been carried on for seven years. Each farmer was interviewed and his attitude toward the sanitary hog production system ascertained. Only 1.5 per cent did the whole job, having completely overcome habit and custom; 38 per cent did parts only; 60.57 per cent did nothing, habit and custom completely dominating.

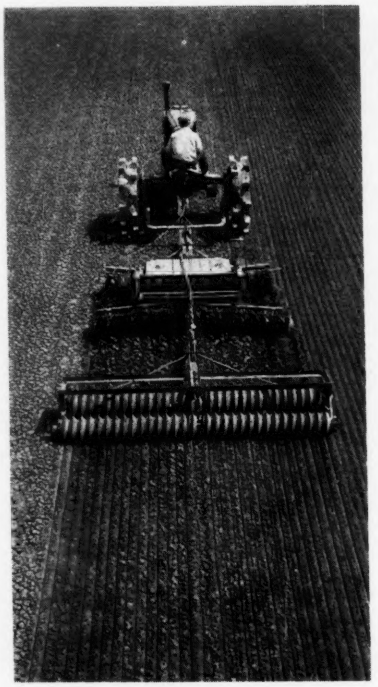
One of the men who made the survey told me that many of the last group said the system was doing more harm than good, because it was making more and cheaper hogs. I have great sympathy with the 60 per cent, not that

[1]Paper presented at the 26th annual meeting of the American Society of Agricultural Engineers, at Ohio State University, Columbus, June 1932.

[2]Professor and head of the department of agricultural economics, Montana State College and Agricultural Experiment Station. Mem A S A E.

I agree with them, but I recognize the human difficulties that grow out of our inability to adjust our thinking and acting to changed technology. This is now and always has been one of the tragedies of human life.

Agriculture is going to be engineered. It is to an extent engineered today, but biological research, engineering research, invention, and design have potentialities which will express themselves in a far more revolutionary way in the future than in the past. Our civilization is gripped in an age of science and machines, and agriculture cannot escape. This engineering attitude of looking at the jobs of farm production, analyzing them, reorganizing them and redesigning them, is now having, and will continue to have, a profound influence on agriculture. It will perhaps modify the direction of biological research and produce problems for the economist by the score, but rightly or wrongly it will be constantly in conflict with habit, custom, and tradition. Let me illustrate what I mean by an engineered agriculture.



About ten years ago Dr Henry C Gardiner, proprietor of the Mt Haggin Land and Livestock Company of Anaconda, Montana, a sheep ranch, conceived the idea that his feeding of alfalfa hay and the winter handling of his sheep were jobs which could be much more efficiently done. He began a series of experiments which as yet are by no means complete, but which have thus far probably reduced the labor and operating cost by 50 per cent and the total economic cost by probably 65 per cent of what they were ten years ago. The custom of handling alfalfa hay for winter feeding was to cut and stack during the summer and haul to the feeding places during winter. Dr Gardener, with a typical engineer's inventive mind, did what an engineer would call "reorganizing the entire job, and rebuilding the plant." The hay-making operations were changed by means of tractor mowers. After curing, the hay was cut into short lengths in the field and stored in self-feeders and sheds instead of hay stacks. The sheep-feeding corrals were relocated so as to be at the head of irrigation ditches. The manure then was free from coarse strawy material and could be scraped from the winter feeding yards and distributed over the land by means of the irrigation water. This engineering approach is going to be generally applied to agriculture in the future, but the job analysis and redesigning of plant and equipment will proceed only as fast as our habits and customs will allow us to make the necessary psychological, social, and economic adjustments. My point, therefore, as an economist, is to recognize that agriculture is going to be engineered.

PROBLEMS FACING ENGINEERS

Agricultural engineering is going to produce many economic and social problems at each step in its advance. The economics of an engineered agriculture will largely be the economics growing out of change and adjustment. At each step in this advance the retarding resistance of custom and habit will have to be met. As an illustration, we have today a reaction, partially resultant from the economic depression and partially due to other causes, which is almost outspokenly putting a premium on inefficiency. The doctrine that scientific research and mechanical advance, especially through tractors and power equipment, have made two blades of grass grow where one grew before, thereby producing a surplus which must be sold at ruinous prices, is almost the same as saying that society should put a premium on inefficiency, stupidity, and ignorance. I say this with full recognition that scientific and mechanical advance have produced new problems which have to be met by new attitudes of mind and new social and economic control.

It may be that engineers can make progress faster than farmers can adjust themselves to it. This is one of the troubles in the world today, and is responsible for the perhaps temporary, but nevertheless serious condition, which we term technological unemployment. Agricultural engineering is just emerging into a stage in which I am sure it will tend to produce the same phenomena in agriculture. For instance, we have shown in our Montana experiments that a 60-hp track-type tractor with its complement of wheat-raising machinery is capable of operating a wheat farm five or six times larger than the average wheat farm of northern Montana. If all wheat farms were suddenly to shift to this type of equipment the work and income of four families out of five would be eliminated. I am satisfied that the same possibility prevails in many other lines of agricultural production. The problem made by engineers for economists and other workers in the field of social science is not only the farm management problem as to what size of farm and combination of enterprise will best fit a given unit of machinery, but also what will become of the people who are displaced, and how can the readjustment take place so as to give all a higher standard of living and human welfare, with the least shock as a result of the change.

ECONOMICS OF ENGINEERED AGRICULTURE

The most outstanding economic aspect, therefore, of an engineered agriculture will be the economic problems attendant to rapid change. These problems, however, are not only economic and social, but philosophic and humanistic as well. We are suffering today from the lack of a philosophy of life which would allow us to feel at home in a rapidly changing, engineered world. Science and technology have disrupted our religious beliefs and controls and greatly changed our social attitudes. I am afraid the charge of our being materialistic at present is true, but I am not quite willing to lay all the blame on engineering and machines. The Greeks had no machines but lots of philosophy; we have many machines but are bankrupt on philosophy. Habit, custom, and tradition will be the foes of an engineered agriculture until there is a wider interpretation and understanding by all of us of the nature of human life, its values, and its interpretation in the scientific and machine age.

What are we to look for in the economics of an engineered agriculture? We can only base our anticipations on discernible trends, which are just now obscured by the most serious depression the world has ever seen. Conservative men like Nicholas Murray Butler of Columbia University have been saying for a year or more that this is not an economic depression but, rather, civilization at the crossroads. One of the most conservative of our journals is the "Magazine of Wall Street." In the issue of June 11 (1932) an editorial writer in this magazine says, ". . . . . whether for good or bad we are in for a period of great social and economic experimentation." Such being the case, the economics of an engineered agriculture is apt to be greatly tinctured with economic experimentation.

Along what lines may we expect to experiment? One may be a managed currency and credit system. The in-

stability of the international as well as the national monetary system, with the disrupting decline of prices, is going to call forth experiments and attempts at what economists are calling a controlled or managed currency. It is doubtful if any country alone can successfully operate credit control. On the other hand, it is doubtful if international goodwill and cooperation have developed to a point which will permit an attempt at international credit stability. At any rate, the smooth, easy, efficient operation of agriculture, which is the ideal of the agricultural engineer, will be absolutely impossible in an economic society which has a wobbly monetary and credit system.

The most fundamental problem in agricultural economic policy in the United States today is the question as to whether, for the next thirty or fifty years, the United States is to operate on a basis of isolation or of international trade. The most important political aftermath of the war has been the growth of nationalism and of isolation areas throughout the world. For political, if not economic, reasons each country is now endeavoring to be as self-contained as possible and to purchase just as little as possible from the outside. The United States, because of its high-tariff policy, unwillingness to adjust international debts, and to loan money abroad, is playing the isolation game just as well as any other country. A free, open, normally competitive world is one of the few things which nearly all economists will agree upon, but political and national forces are different from economic forces, and I am afraid that we will live in a world of nationalism and isolation for the next few decades. If such is to be the case we will have to largely eliminate the export production of both manufactured and agricultural commodities. At present about forty million acres of our agricultural land is given over to producing our agricultural exports, and it is estimated that five million souls occupy these lands. If a part of this production is to be contracted, you can see we are in for a terrific agricultural shock. It can only be averted by ourselves as well as other countries lowering their tariffs so as to facilitate world trade adjustment, or by cancellation of the war debts, thus to bring about free commercial interchange. The isolation policy, however, will probably affect the United States the least of all countries because we are the largest free-trade area in the world. We could still have a high and rapidly rising standard of living on an isolation basis, if we would be willing to accept the idea of national economic planning and coordination of industry. Agriculture cannot be fitted into a permanent national isolation program without new institutions and probably production control.

ENGINEERED AGRICULTURE NEEDS FEW WORKERS

An engineered agriculture is going to require fewer workers than a mode-of-living agriculture. It has been estimated that we could easily release two million of the six million families now on farms for other productive industry, and thereby improve both the status of the four million families remaining on the land and increase the productivity of society as a whole. A question arises as to where the two million families would go. How can they be fitted into new walks of life without great human sacrifice? This comes very near being the crux of the agricultural problem. The answer is to be found in the decentralization of industry and shortening of the working day. The machine age has taken two very fundamental things away from the urban worker, namely, security and the opportunity for constructive use of leisure time. Industry must be reorganized so as to return these values to its workers. This can only be done through decentralization.

A most significant thing in American life today is the typical Mormon village. When Brigham Young settled his band on the Salt Lake Desert he laid out villages with blocks and streets in the traditional way. It was necessary that the people live in villages for protection against the Indians, but he made one important difference. The blocks were not cut into lots. Each occupant instead of living on a lot, lived on a town block of a little more than two acres. If industry could decentralize into villages of not more than a hundred thousand population with the factories at the center and the people living in Mormon village style, on one and two-acre suburban blocks for 15 or 20 miles around, then we would bring back to industry security for the workers and opportunity for constructive use of their leisure time. This is all made possible because of the machine age, rural electrification, the Model A instead of the Model T, mass production housing, etc. If we are to have shorter working time, then the worker can, we will say, work two days on his job and be off the third day, which time he can devote to his suburban lot. It has been estimated that this activity would contribute food for the family which if purchased at retail prices would cost between $200 and $400. No doubt from now on we will hear much about the decentralization of industry, and the changes which I have just described.

If the opportunity can be given for a high standard of living through the industrial suburban life, to any number of workers, including the surplus farm population, thereby increasing the flow of all kinds of goods contributing to the general welfare, then this competition will tend to remove the surplus, to displace farmers. It will tend to bring about a new competitive level which will insure the remaining farm population an equally satisfactory standard of living. The ideas of decentralization in industry, and of the suburban type of life have possibilities of giving entirely new direction and new stability to American life. It cannot, however, be attained without modification of the anti-trust laws, thereby allowing industries to institute industrial economic government and control; the establishment of governmental economic judicial bodies to prevent monopoly prices; and some type of national planning and industrial coordination.

HIGHER PREMIUM FOR MANAGEMENT

An engineered agriculture will pay a much higher premium for management than is now the case, and thereby change the plane of competition between farmers. It will require much more skillful use of credit, because it will greatly increase the capital investment per farmer. When the family farmer loses through lack of management, or whatever the reason may be, he principally loses his labor which does not command a very high hourly rate. On the other hand, when the farmer who is using capital equipment loses through mismanagement, not only labor is lost, but capital as well.

An engineered agriculture will require a new type of engineering—farm management, research, and experimentation. As new machines and new processes are developed, we can assume that they will either adjust themselves to the prevailing organization, size, and type of farm, or the farm organization and size will be adjusted to the new techniques and equipment. Tractors and equipment can be made in various sizes so as to fit different sizes of farms, but even so, there must be one of these sizes which is more efficient than the others. Regardless of the resistance of the moment, economic forces will keep tending toward adjusting the farm and the equipment in proportion to give the combination which will produce at lowest cost. Joint efforts of agricultural engineers and agricultural economists, to further this adjustment, in my judgment further require setting up experiments on farms; not experimental farms, but experiments in farming. Investigators in these fields should be given the funds with which to conduct the kind of experiments cited in the case of Dr Gardiner, earlier in this paper. This line of experimentation would begin by engineers and economists making a thorough engineering and economic analysis of a particular kind of farming. Then on the basis of engineering and economic principles, plus their inherent inventive capacity, they might work out and experiment on a new kind of farm plan which would take advantage of the best biological science, engineering technique, and economic organization. If the experiment were successful, it would

become a beacon light for the guidance and direction of agriculture in an area of similar farms.

A proposal for this type of experimentation plus regional and national agricultural economic planning was contained in a bill introduced in Congress a year ago by Congressman Christgau of Minnesota. Mr. Christgau realized that his bill was far in advance of the current thinking of the present day. He introduced it as a pioneering project, rather than with the expectation of its winning immediate approval.

No one can forecast what the economics of a completely engineered agriculture will be, because no one knows whether or not there will ever be an engineered agriculture in its fullest sense, or what would be its characteristics. The chief lesson from history at this time is that we know little of the laws which control human mass behavior—our motives, habits, and customs.

Economists recognize no limits to the sweep of science, or to its application to human wants and desires through the medium of the technology of engineers. We are coming more and more to think that the ultimate ends and objectives of life are to be found in philosophical, religious, esthetic, and ethical values. It is our job, as engineers and economists, to cooperate more closely in the future and to coordinate our activities toward the development of those values.

(EDITOR'S NOTE: In the closing paragraph of his remarkable paper Mr. Wilson strikes a keynote which must more and more challenge our attention. The past three decades have witnessed the greatest industrial advance and the greatest material prosperity the world has ever known. Now we are beginning to take stock of ourselves and to reach the conclusion that we have sadly neglected those spiritual values, which, after all, make up the true happiness and well-being of human existence. We are just coming out of a world crisis that has seriously threatened our civilization. The experience should be sufficient to convince any thinking person of the great danger of too much stress on material values, and the great need of all mankind for a more intensive striving for spiritual values.)

The Refinancing of Drainage Districts[1]

By Geo. R. Boyd[2]

IN COMMON with enterprises of every sort, a great many drainage districts are in financial difficulties. Incomplete returns of the 1930 census show that 778 drainage enterprises were in arrears in payment of bonds and interest in 1930, while 1,721 enterprises have some lands on which drainage taxes have not been paid. The capital invested in enterprises which are in arrears is about 80 million dollars, while that in enterprises not in arrears but with some tax delinquent lands is over 90 millions.

Studies now being made by the U S D A Bureau of Agricultural Engineering indicate that the delinquencies on bond interest, principal payments, and drainage taxes have increased greatly in the two years which have elapsed since the census figures were obtained. These studies also show that some lands were unable to pay their drainage taxes as early as 1922, and that tax delinquencies have increased during the years since then, to such an extent that only a small percentage of landowners were able to pay their assessments in 1931. In many drainage districts, considerable areas have been foreclosed in drainage tax sales; some districts have gone into bankruptcy, and in other districts the lands have been taken over, in whole or in part, by representatives of the bondholders. At the present time there is a probability that serious losses will be suffered by both landowners and bondholders in many districts.

There are many causes for these financial difficulties, some of which are interlocking and cumulative. Among those which are most readily apparent are:

1 Construction at times of peak costs and prices. As a general rule, those districts which were organized prior to 1915 have been successful. There are two reasons for this success: (a) Crop and land values were not sufficiently high to encourage large drainage costs per acre, and (b) the landowners secured exceptionally high prices for their products during a considerable part of the time in which they were paying off their drainage taxes. On the other hand, districts established during the period of high prices generally have high costs per acre and their assessments have fallen due at a time when prices for agricultural products were decreasing.

2 Failure of the drainage improvement to do all that was expected of it. Insufficient outlets and lack of proper maintenance have sometimes resulted in such poor drainage as to preclude the payment of drainage taxes.

3 In some districts inadequate drainage statutes, poor management, or dilatory enforcement of the collection of taxes, have resulted in financial distress.

4 Many districts having large areas of cutover land were organized with the idea that such lands would be quickly cleared and put into cultivation. Generally the development of such lands has been slow because of the difficulty of obtaining settlers, and it has become almost impossible to collect the taxes.

5 The principal cause of the present distress is found in the great reduction in farm income which has occurred in recent years. The total farm income for 1931 was about 40 per cent below the average for the five preceding years. Under such conditions it is not surprising that many landowners have not been able to pay their drainage taxes.

A study of the causes of the present predicament of drainage districts would be of interest and might serve as a valuable guide in the organization of new districts, but the immediate problem is the solution of the difficulties which are facing both landowners and bondholders. Some economists hold that the only solution is to let the lands be sold for taxes, reverting to the state when there are no bidders, thus wiping out so much of the indebtedness on the land that the new owner may be able to make a living. Such a course may be the only solution for some districts, but it seems that everything possible should be done to find some method more favorable to the present owners and the bondholders.

The matter of rehabilitation is entirely a matter of salvage. It is not constructive except in the sense that it endeavors to make all the savings possible for each of the interested parties. Means and methods may be used which would be entirely out of place in a financial plan for a newly-organized district. Although each district must be treated individually, the following are some general principles which might apply to all cases of attempted rehabilitation:

1 Any voluntary or extra-legal plan of refinancing, in order to stand a chance of being successful, must be acceptable to both landowners and bondholders. Generally, it will take the form of a compromise determined by and between representatives of each group. While it probably would be impossible to draw up any plan which would be satisfactory to all parties, it is inadvisable to undertake the execution of any plan not acceptable to 90 per cent of both landowners and bondholders.

2. Since any rehabilitation plan generally involves sacrifices by both landowners and bondholders, it is not

[1]Paper presented at a meeting of the Land Reclamation Division of the American Society of Agricultural Engineers at the 26th annual meeting held at the Ohio State University, Columbus, June 1932.

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always possible to secure the voluntary adoption of a plan, and in such a case, the only recourse is bankruptcy and the appointment of a receiver for the district. Such proceedings may be expensive, but the receiver under court supervision has entire control of the affairs of the district and has authority to enforce his plans.

3 Any successful rehabilitation plan must be based upon the ability of the land to pay. One way of calculating this is to average the crop yields per acre and the prices received over a period of years, to find the average gross income per acre. From this are subtracted the cost of production, state and county taxes, interest on mortgages, and maintenance and repair costs of drainage improvements, leaving a sum which may be used to pay off drainage indebtedness. The length of time during which such payments should continue is a matter for decision in individual cases. Another method which has been used differs from the one just given in that, instead of using average figures covering a period of years, the yearly payments vary with crop yields and prices for each year. Another varies the amount of the yearly payment in accordance with the value of the dollar. Doubtless other methods can be devised to carry out what is thought to be the basic principle of rehabilitation, the limitation of the annual payments to sums which the land can earn.

4 All plans for rehabilitation should insure that no penalties or additional costs will be inflicted upon landowners who have no delinquent taxes.

5 Rehabilitation plans should be undertaken as soon as financial difficulties develop. Delays are dangerous, and rehabilitation becomes increasingly difficult as delinquencies increase.

6. Where the rehabilitation plan contemplates the buying in of lands delinquent as to drainage taxes, it is imperative that funds be provided for district operating expenses and for state and county taxes to cover the period which must elapse before such lands can be sold.

7 Often, especially where rehabilitation has been too long delayed, a fund must be provided in the plan for repair of the district improvements as well as for maintenance and operation.

8 Refinancing by means of refunding bond issues entails greatly increased costs for interest charges. Likewise, long-term bond issues are expensive unless interest charges are very low.

It is apparent that, while it is not difficult to evolve the principles given above, their application to specific problems is entirely another matter. To develop a rehabilitation plan which will be practical, which will minimize the losses, which will be fair and just to all parties, and which will be acceptable, if not entirely satisfactory, to both landowners and bondholders, is a man-sized problem.

At various time during the past two years bills have been introduced in Congress which have for their purpose the relief of drainage and irrigation districts. In a general way they provide that the outstanding bond issues be written down, where necessary, to the actual or economic value of the lands in the district, that the government then pay such bond issues and receive in return an equal sum in 40-year bonds, at 3 per cent interest, of the drainage or irrigation district.

If such federal legislation were enacted, much investigational work would be necessary to determine the amount of the loans for which the lands would provide security. Also, in many, if not in all, states enabling legislation would be necessary before drainage districts could issue bonds that would obtain the advantages offered by the government. It appears that, because of the time required for investigations and amendment of state laws, the proposed legislation would not accomplish what is sought—the immediate relief of distressed landowners. Probably three or four years would elapse before the proposed loans would be obtained by the districts, and in that period most of the delinquent lands would have been lost to their present owners.

If it be assumed that it is the duty or the privilege of the federal government to furnish such relief, it would seem that it would be sufficient to provide funds for the payment of current assessments for bond principal and interest, and to establish some method of repaying such advances that would not require the revision of state laws. If such legislation could be set up, it would give more immediate relief, and a greater number of districts could be helped than seems possible under the proposed legislation. Under such a scheme it would still be necessary for individual drainage districts to work out their own final salvation, because the governmental relief would be only temporary in character.

Paving Garden Helps Control Weeds

By W. G. Kaiser

UNSIGHTLY, troublesome, useless plants—weeds, in other words—are familiar to all agricultural engineers. Of current interest in this conection is a report of the U. S. Department of Agriculture which says that "gardens ultimately may be paved instead of plowed!"

Concrete slabs used as a garden mulch

"A permanent mulch keeps out weeds and stimulates plant growth," say the expert gardeners of the U. S. Department of Agriculture, and this is the reason why the Department is now experimenting with permanent mulches, including concrete slabs something like the units with which houses and other buildings are built. The permanent mulches, as shown in the accompanying photograph, cover the surface of the ground, except for a small space where the plants grow.

At the Arlington, Virginia, U S D A experimental farm, according to a recent report, "beans, peas, strawberries and various other small fruits have grown as well under the permanent mulch as with ordinary cultivation. Blocks a few inches thick and 9 and 12 in wide cover the ground, with rows 1½ in wide between them. The permanent mulch conserves moisture and controls weeds. In addition, it warms the soil earlier in the season and keeps it warm longer in the fall. Rainfall gets into the ground along the rows between the blocks.

"Soil covered with the blocks since 1928 has continued productive. Government scientists believe it possible that no ill effects will be found, because they know that trees grow successfully under city streets and sidewalks, which constitute a permanent mulch."

Artificial Drying of Agricultural Products[1]

By R. B. Gray[2], W. M. Hurst[3], and E. D. Gordon[4]

ARTIFICIAL DRYING or dehydration of some agricultural products is essentially an economic measure accepted by growers, sellers, and consumers for protection of their pocketbooks. The first recorded reference to artificial drying seems to be of a farmer in England, who, in the sixteenth century, dried his wheat to prevent spoilage when he wanted to keep it for long periods to obtain a good market price.

If sufficiently low-cost methods of drying can be developed, they are apt to have a profound influence on the agriculture of the country. There are many areas advantageously located in low-freight-rate zones where large crop yields are possible, but where climatic conditions are such that certain crops cannot be cured with reasonable certainty after they are grown.

The application of the direct-heat principle to grain and forage drying has probably been the most outstanding development in recent years. However, future research may show the desirability of partial drying of forage in the field, or of wilting to reduce the weight in hauling and the total quantity of water to be removed by artificial means. Research dealing with the fundamental requirements involved in the evaporation of moisture from such substances may indicate more economical ways of drying, such as the application of the vacuum principle and still other methods as yet unimagined.

Dehydration, according to Webster's dictionary, means the "rendering free from water." However, the evaporation of all moisture from agricultural products is not necessarily desirable or practicable. It has been found that by reducing the moisture content of various commodities to between 10 and 25 per cent, depending upon the commodity, the deteriorating action of such agencies as bacteria, yeasts, molds, insects, enzymes, and probably certain purely chemical reactions, can be arrested. In the case of some products, particularly dried fruits, a preservative such as sulfur dioxide is necessary because of the commercial impracticability of securing sufficiently low moisture content.

The removal of moisture has been divided into three classes: (1) Sun drying; (2) evaporation, brought about by artificial heat augmented by natural draft; and (3) artificial drying or dehydration, wherein the drying is accomplished by artificial heat circulated by mechanical draft.

In each case it is a question of converting into water vapor by heat a certain percentage of the moisture of the product to be dried, and carrying away the **water vapor by air currents.** The latter case (artificial drying) only will be considered in this paper.

Naturally, the higher the temperature, the drier the surrounding air; and the higher the air velocity, the more rapidly evaporation takes place from a free water surface. But with the complex cellular structure and chemical nature of fruits, vegetables, grain, and forage crop tissues, evaporation is retarded to a lower rate than from a free water surface. In some products where conditions are such that surface evaporation exceeds the rate of moisture diffusion to the surface, the surface becomes dry and hard, and the moisture escapes with difficulty. A sort of case-hardening takes place. Because of this fact, intermittent drying or the use of high-humidity air may be necessary with some products.

UTILIZATION OF HEAT

There are three systems commonly used in the application or utilization of heat for drying agricultural products. With the indirect radiation method, heat is transferred to the product or to the drying air through the intermediate agency of a steam boiler and steam heating coils. When the direct radiation method is used, radiant heat from metal walls or from flues connected with the combustion chamber of a furnace is employed. The direct-heat method, the application of which is of comparatively recent date, utilizes the products of combustion direct from a coke or oil-burning furnace. The latter method is usually the most efficient and is preferable when the product to be dried will not be injured by coming in direct contact with the products of combustion from the furnace and when fire hazards are not too great. With either the direct or indirect-radiation method, almost any available fuel may be applicable, but a clean-burning fuel is essential with the direct-heat method. While the cost of electric energy for heating is prohibitive in drying most agricultural products at the present time, its use for this purpose may be expected to increase with improvements in drying equipment and methods.

HISTORY

While the process of drying certain products of the soil may be considered "as old as the hills," it was not until comparatively recent years that experimental driers were built in this country, the scope of the field enlarged, the need of fundamental investigations realized, and the manufacture of commercial units begun.

The first reference to artificial drying seems to be that recounted in "Horse-Hoeing Husbandry," by Jethro Tull, published in 1829; the actual drying probably having been done about 1700. This was occasioned by the fact, as related by him, that "a farmer cannot thrive who, for want of money, is obliged to sell his wheat under 5 shillings a bushel, but if he will sell dear, he must keep it when cheap." He goes on to relate that a neighbor of his in Oxfordshire, England, dried wheat for many years by placing it "upon a haircloth in a malt kiln with no other fuel than clean wheat straw, never suffering it to have any stronger heat than that of the sun. The longest time he ever let it remain in this heat was 12 hours and the shortest time about 4 hours; the damper the wheat was and the longer intended to be kept, the more drying it requires; but how to distinguish nicely the degree of dampness and the number of hours proper for its continuance upon the kiln . . . . was an art impossible to be learned by any other means than practice."

It should be noted here that the reason for his drying was to prevent spoilage when kept for long periods of time.

The sun is doubtless the oldest drier and is used at the present time, but cannot be depended upon to furnish heat for drying at all times, as is necessary. To dry commodities regardless of the weather it was necessary to introduce artificial methods. Probably one of the earliest attempts at artificial drying in the United States was for drying prunes, about 1880. A few years later artificial methods were used in drying walnuts[5]. Hon Russell Heath referred to the methods used in artificially drying walnuts in the late 'eighties, as follows: "In handling the nuts I cure in dry houses by artificial heat, heating sufficient to evaporate the water and set the oil of the nut. When this is done, the nuts will keep sweet for an indefinite time."

[1]Paper presented at the 26th annual meeting of the American Society of Agricultural Engineers, at Ohio State University, Columbus, June 1932.

[2]Chief, division of mechanical equipment, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. A.S.A.E.

[3]Associate agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Assoc. Mem. A.S.A.E.

[4]Associate agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. A.S.A.E.

[5]California Agricultural Experiment Station Bulletin No. 376.

Early methods apparently were not entirely practicable as they were used only in a few cases until about 1900, when renewed interest was manifested. At about that time it is stated that the Corona del Mar Ranch at Goleta, California, dried walnuts in an old prune drier. Now driers are perfected to the extent that large quantities of walnuts on the Pacific Coast are artificially dried, as well as fruits and vegetables.

FIRST ATTEMPTS AT ARTIFICIAL DRYING

Probably the first attempts at artificial drying of forage crops were inaugurated by the U S Department of Agriculture in 1910, at Hayti, Missouri[6]. A year later Arthur J Mason built a drier at West Point, Mississippi. The Bayley Co of Milwaukee, Wisconsin, in 1915, built a dehydrator for the McCracken Land Co, of Houston, Texas. The Louisville Drying Machinery Co, of Louisville, Kentucky, started experimental work about 1915. From 1915 to 1925 there seemed to be little interest in this work with about the only work going forward being that of Mason and the Louisville company, who were making improvements on their driers. During 1925 the interest in dehydrators gained momentum and has been getting larger each succeeding year. The Louisiana Agricultural Experiment Station was probably the first state experiment station to begin investigational work on this subject. The U S Department of Agriculture, other state agricultural experiment stations, commercial concerns, and various individuals have each spent considerable sums of money in an effort to bring about this development.

With the spread of the combine in the humid sections it was found necessary to investigate grain drying. While commercial grain driers had been used for many years in terminal elevators and flour mills, artificial drying of grain has never been practiced to any extent on the farm. This is due in a large measure to the high initial cost and the extreme seasonal demand for the use of grain-drying equipment. The introduction of the windrow harvester has made it possible to obtain grain sufficiently low in moisture content for safe storage, in areas where artificial drying was at one time considered essential for the successful use of the combine. However, the use of grain-drying equipment is still of considerable importance to country and terminal elevator operators.

The early attempts to dry corn artificially are probably associated with the development and use of grain driers, as this type of equipment is suitable for drying practically any cereal grain. The drying of seed corn on the cob, however, is not possible with this type of equipment as shelled corn or small grain is held in thin layers in the driers for uniform drying. Several state experiment stations have done considerable work in an effort to develop suitable equipment and methods for handling seed corn during wet seasons.

[6]"Artificial Dehydration of Forage Crops," by Harold T. Barr, AGRICULTURAL ENGINEERING, Vol. 12, No. 6 (June 1931).

Commercial grain driers have been used for many years in rice mills in the South and such equipment seems to be essential when the combine is used for harvesting rice. The U S Department of Agriculture began a study of some of the mechanical and economic factors involved in rice drying in 1929 and tests have been made on both experimental and commercial units. In 1926 investigational work was begun on cotton drying and two types of driers for seed cotton have been developed by the U S Department of Agriculture.

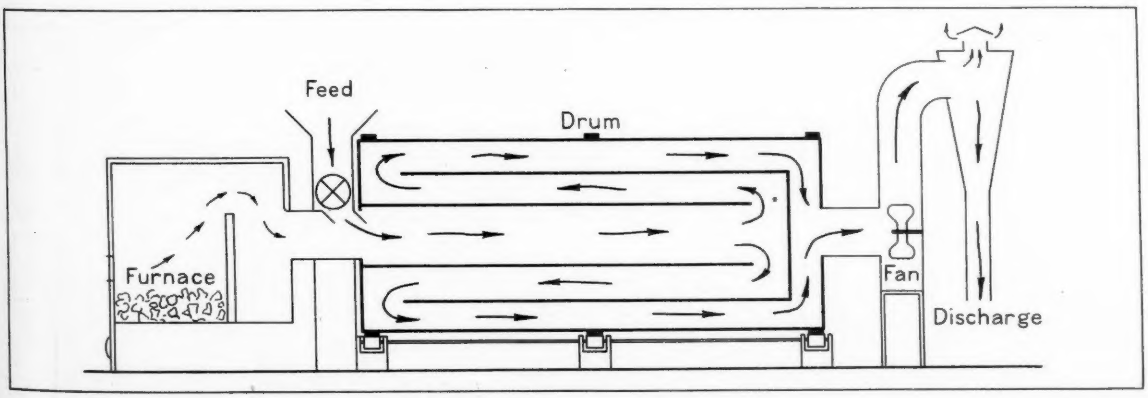
IMPORTANCE OF DRYING

There are approximately twelve state agricultural experiment stations with active projects dealing with the artificial drying of farm products. The U S Department of Agriculture, as well as three or four foreign governments, is engaged in investigational work on this subject. The interest which has been taken in this subject has been brought about in some cases by the introduction of new methods and equipment for harvesting grain crops. In other cases it has ensued from a desire to eliminate weather hazards at harvest time, to insure safe storage and transportation of otherwise perishable products, to reduce weight in shipping, or to obtain a uniform high-quality product.

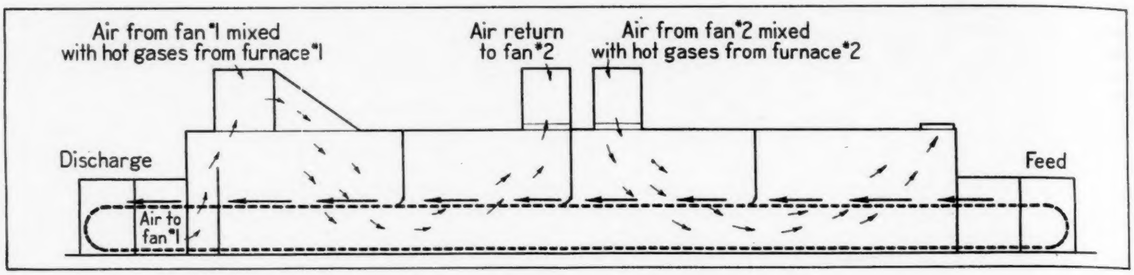
While there is little statistical material available showing the quantity and value of products dried annually in the United States, figures are available which will give some idea of the importance of this method of crop processing. A survey by the U S Department of Agriculture in 1918 disclosed the fact that there were in this country at least 250 grain elevators equipped with grain driers having a total capacity of about 3,345,000 bu of grain per day of 24 h. During the World War 8,905,158 lb of dried vegetables were shipped to the U S Army overseas. In 1929 dried fruit products totaled approximately one billion pounds, of which a considerable portion was dried artificially. During the same year about 3,847,000 lb of dried peaches and 3,655,000 lb of dried pears were exported. The average annual production between 1923 and 1927 in pounds of dried products total 24,840,000 lb for apples, 43,120,000 lb for apricots, 45,000,000 lb for peaches, and 6,536,000 lb for pears. In 1925 the production of dehydrated prunes totaled 290,000,000 lb.

DEVELOPMENTS

Application of the direct-heat principle to grain and forage drying has probably been the most outstanding development in recent years. Some of the early experiments made by manufacturers indicated that in the design and construction of grain driers it was necessary to hold the grain in thin layers or columns for uniform drying and to permit the circulation of a large volume of air through the grain without excessive power requirements. In seed cotton drying a great deal has been accomplished in the development of inexpensive equipment.



A diagram of the modified revolving-drum type of forage crop drier



A diagram of the apron-conveyor type of forage crop drier

GRAIN DRYING

Cereal grain with a moisture content not in excess of 14 per cent is usually considered dry enough for safe storage. The moisture content of damp or wet grain when brought to a drier may vary from 14 to 25 per cent, but the average may be considered as 18 per cent. Approximately 2 lb of water must be evaporated in order to reduce the moisture content of one bushel of wheat from 18 to 14 per cent. It is estimated that 1100 Btu are required to evaporate one pound of water from grain. The combustion of coke usually produces about 12,500 Btu per pound. With a thermal efficiency of 50 per cent, which may be considered as an average for grain driers, one pound of coke would be required for each 3 bu of grain.

Due to the compact nature of grain, it offers considerable resistance to the flow of air. As the drying air passes through such material, moisture is evaporated, the air is cooled, and the capacity of the air for removing moisture is reduced, causing uneven drying. In order to prevent excessive power requirements and to obtain fairly uniform drying, the grain is held in such a manner that the drying air has to pass through only a few inches of grain.

The quantity of air supplied per unit of time will vary with the different makes and types of driers as well as with the kind of grain dried, but tests indicate that approximately 100 cu ft of air per minute per bushel of grain is usually supplied in commercial driers. High air velocity is conducive to rapid drying, but an increase in air velocity will not always result in a proportionate increase in evaporation of moisture from grain. This is due to the dense structure of the kernels which prevents rapid diffusion of moisture to the surface.

Tests which have been made on commercial driers show that the cost of drying, exclusive of overhead charges, varies from approximately 0.5 to 0.75 c per bushel, with an average reduction in moisture of 3.5 per cent. The overhead cost per bushel of grain will depend almost entirely on the number of bushels dried annually. In other words, the overhead cost involved in drying 10,000 bu per season would be about twice as much per bushel as when a drier handled 20,000 bu per season.

COTTON DRYING

The physical characteristics of seed cotton, the raw product as harvested from the cotton field, are such that drying temperatures must be limited to below the boiling point of water in order to prevent injury to the delicate fibers. The U S D A Bureau of Agricultural Engineering secured a public patent on a process which has become generally known as the "government process," which embodies the following principal features: (1) Temperature is maintained preferably between the limits of 160 to 200 deg (Fahrenheit); (2) the volume of heated atmosphere employed per pound of damp seed cotton is varied between 40 and 100 cu ft; and (3) the period of exposure or time in which the damp seed cotton is subjected to the continuous flow of heated atmosphere varies between 45 sec and 3 min.

The specific gravity of the seed cotton has enabled the Bureau to develop a vertical-tower type of drier which has seventeen or more horizontal sheet metal floors and through which the cotton is blown by means of a continuous blast of heated atmosphere conforming to the process requirements. This type of drier employs only standard cotton ginning fans and other apparatus well known to the trade, and during the past season of 1931 approximately 10,000 bales of damp seed cotton have been very successfully dried at commercial gins in the long staple regions of the Mississippi Delta. Such a widespread interest has been manifested in this vertical drier that the present indications point to the construction of at least 100 more during the coming season. Several of the more enterprising manufacturers of cotton-ginning equipment have produced for sale driers of the type designed by the Bureau. It is interesting to note that the capacity of this drier is approximately 9,000 lb of damp seed cotton per hour and that it costs only about one-third the price charged for other types of commercial driers having a similar capacity.

FORAGE DRYING

Forage is bulky and 70 to 80 per cent of the weight of crops cut for hay, such as alfalfa and grasses, is water. This means that approximately two tons of water must be evaporated to obtain one ton of dry material. It is estimated that approximately 1100 Btu are required to evaporate one pound of water from forage plants. The combustion of coal produces approximately 14,000 Btu per pound and fuel oil about 19,000 Btu. If the thermal efficiency were 100 per cent, 315 lb of coal or 232 lb of oil (31 gal) would be required. As 50 per cent may be considered as an average overall thermal efficiency, 630 lb of coal or 62 gal of oil would be required.

Atmospheric air always contains some moisture. The volume of air required to carry off the evaporated moisture as well as that resulting from combustion must be calculated and the amount of moisture in the air taken into account. A rough approximation indicates that about 2,000,000 cu ft of air, measured under atmospheric conditions, would be required to carry off the moisture in obtaining one ton of dry forage. The exact amount would of course depend to a large extent on the type of drier and temperature of the drying air.

The design of forage driers has in general followed conventional lines, that is, the principles involved are quite similar to those which have been used for many years in other industries. Of course, there have been improvements and modifications in the adaptation of such equipment to forage-drying conditions, but practically all of the driers may be classified either as of the revolving-drum, tray, or apron-conveyor type. With the revolving-drum type the forage must be chopped into short pieces, whereas with the apron-conveyor or tray type it may be dried whole. A high drying-air temperature, short period of exposure, and rapid drying are characteristics of the drum drier as used for forage. The characteristics of the tray and apron-conveyor types are low temperature, long period of exposure, and slow drying.

The simple drum drier usually consists of a drum or cylinder from 6 to 8 ft in diameter by 40 to 50 ft in length, mounted with its axis horizontal and in such a manner that it can be revolved at the desired rate of speed. Where

the direct-heat method is used, an oil or coke-burning furnace is installed at one end and a dust collector, or chamber, for receiving the dried forage, at the opposite end. In some cases the dried material is removed from the dust collector by a conveyor, whereas in other cases the fan used for drawing the products of combustion through the drier is used for the purpose. The green forage is fed into the drier at the furnace and as the drum revolves, the material is picked up by flights mounted on the inside of the drum. Each time the material is picked up and allowed to fall through the stream of hot gases passing through the drum, it is moved towards the discharge end of the drier. In some cases this type of drier consists of three concentric drums, so arranged that the forage must pass through each drum before it is discharged from the drier.

All apron-conveyor driers are similar in that the forage is conveyed through the drying chamber on an endless screen-wire conveyor. Provisions are usually made for uniform distribution of material on the apron. In one case this is done by a ribbon-forming machine. In another case the forage is compressed slightly by a plunger which forms a mat of uniform density and thickness. The products of combustion are drawn from the furnace, mixed with outside air in a mixing chamber, and forced through the hay by one or more fans.

In one type of tray drier the green forage is loaded on trays by hand, with forks, allowed to dry and then removed to make way for a fresh charge of green material. In order to eliminate some of the hand labor involved and to facilitate rapid drying, experiments have been made in which the forage is loaded in trays, the trays moved through the drying chamber, and then dumped by mechanical means.

COST OF ARTIFICIAL FORAGE DRYING

Due to the large number of variables involved, it would be impossible to make any definite statement regarding the cost of drying forage artificially. However, tests made on several commercial driers show that the cost of power and fuel may vary from approximately $3.50 to $9.85 per ton of dry forage when the moisture content of the forage is reduced from approximately 70 to 12 per cent. When labor was included the total operating cost varied from approximately $4.80 to $12.35 per ton of dry forage.

The actual operating cost of drying forage will depend in part upon the type of drier used, condition of the forage to be dried, skill of the operator, and weather conditions. No definite statement can be made as to the relative efficiency of different types of driers. In general, the simple drum drier can be operated with less power and fuel than other types. However, some of the large apron-conveyor driers may be operated at a lower cost per ton of forage dried than the revolving-drum type. The overhead expenses are, as a rule, much higher on the apron-conveyor type because of the high initial cost, which tends to increase the total cost of drying. The initial cost of drum drier installations may vary from approximately $5,000 to $10,000, whereas the apron-conveyor types may vary from $10,000 to $30,000.

Methods and equipment used in harvesting the crop and getting the material to the drier, as well as the efficient utilization of labor in the field and at the drier, also have a considerable influence on cost of producing artificially dried forage.

In making a comparison of the performance of different types of driers, the kinds of material dried should be given consideration. Succulent plants with small stems and leaves, such as meadow grasses, clovers, and alfalfa, frequently will dry more quickly and uniformly than soybeans and other similar rank-growing plants.

One way of appraising the value of artificially dried forage is to compare the market value of alfalfa hay by grades. In this connection it is assumed that the highest possible grade of alfalfa hay, which is U S No 1 extra leafy, could be obtained by artificial drying, provided, of course, that the forage was cut at the proper time and that it was not injured during the curing and handling processes. In addition, it is assumed that the average grade of alfalfa hay sold on the market is U S No 2. The average difference in price of carload lots on the Kansas City market, and U S No 1, extra-leafy alfalfa hay, from August to December, in 1927, was $6.65. In 1928 the difference was $7.45 for the same period. While insufficient data are available to compare the market value of these two grades in 1929 or 1930, the difference was approximately $5.50 in 1931. From this it would appear that artificially dried hay might be expected to bring from $5.00 to $7.00 per ton more than the average alfalfa hay which is placed on the market.

While we have no test data to show the difference in nutrient value of the different grades of hay, the opinion seems to be that the price difference is justified.

RESEARCH PROBLEMS IN FORAGE DRYING

Forage is a product of relatively low market value in comparison with other agricultural products which are dried artificially. It is bulky and has a high moisture content when cut. Unless such feed can be produced at a lower cost with an artificial drier than by natural drying, or unless a product of much superior quality can be obtained, there appears to be a limited field for the use of forage driers. It appears that activities should be concentrated on an effort to increase the efficiency of driers, reduce the overhead cost by simplifying the equipment, and produce a high-quality product, the increased value of which will compensate for the cost of artificial drying.

In an effort to determine some of the fundamental factors involved in forage drying it would seem desirable to give consideration to the following points, some of which have been investigated:

1 Maximum temperature of the drying air or products of combustion and optimum period of exposure without injury to the product, for driers of different types. In the final analysis the cow is the judge, so tests should be made as to palatability as well as to nutrient value.

2 The possibility of controlling the moisture content of the dried product, as discharged from the drier, by the temperature of the exhaust air.

3 The desirability of partial drying or wilting in the field to reduce the weight in hauling and to reduce the total quantity of water to be removed by artificial means. There is, however, apparently an optimum stage of growth or degree of wilting for best results. The degree and method of wilting seem to be of special significance as green forage when brought directly to the drier will at times dry more rapidly than similar forage which has been partly dried in the field.

4 The effect of different weather conditions, methods of harvesting, and different atmospheric conditions, as they vary throughout the day, when forage is harvested, on the rate of artificial drying and quality of final product.

5 The use of a heat-treating process in which steam formed in the plant cells would rupture the cell walls, permitting more rapid drying by artificial means.

6 The use of hot crushing rolls to rupture the stems and to heat the forage. This would tend to cause the moisture to be converted into steam quickly and probably effect a higher thermal efficiency.

7 Determination of the optimum moisture content of forage for safe storage when chopped, when baled, or when stored loose in the haymow.

8 Practicability of the application of vacuum drying which has been used for other products.

Other possibilities which have been suggested include the drying of green forage in bales in a similar manner to that of lumber; the application of an initial heat-treatment for checking the action of molds, bacteria, enzymes, and chemical reactions on the keeping properties of forage which is otherwise allowed to dry under natural conditions, either in bulk or layers, in a shed or haymow; practicability of pre-drying with unheated air, and that wilting in the shade might give the final product different properties than wilting in the sun.

Irrigation Practice in the Eastern States[1]

By F. E. Staebner[2]

INVESTMENT in spray irrigation in the eastern states of the United States is probably considerably greater than that in surface irrigation, and the interest in spray irrigation is proportionate.

The crop grown has an important effect upon the frequency of irrigation. Strawberries, for example, may need irrigation once every three days during their fruiting period, if the weather is hot and dry, but for the remainder of the growing season irrigation may be required much less frequently.

Most growers now favor applying a thorough irrigation only when needed, but a few still persist in the belief that a little moisture should be added every day, or every other day, during a drought. Some who follow this practice obtain good crops. This practice tends to encourage shallow rooting unless the water applied is sufficient to maintain suitable moisture throughout the natural root zone of the crops. It is not definitely known whether a crop that had been started by shallow and frequent irrigation would be worse off, in case of pump or engine failure, than if more thorough waterings had been applied at less frequent intervals. Fortunately, pump and engine failures seldom occur.

Most irrigators pay little or no attention to the time of day when they irrigate, though some growers insist that spray irrigation should be done only at night, in the late afternoon, or on cloudy days. In large installations, irrigating only at selected periods is impossible; but no harmful results seem to follow from disregard of the time of irrigating.

While less money is invested in surface irrigation in the eastern states than in spray irrigation, yet there is a large and growing investment in surface irrigation, and the acreage covered by this method is unquestionably greater than that watered by spray irrigation

The most common type of surface irrigation in the eastern states is furrow irrigation. This type is employed in the irrigation of citrus orchards, sugar cane, potatoes, and vegetables.

In orchard irrigation, a single furrow between the tree rows is often used. In ridged citrus orchards this may be the only feasible method, but it does not permit the entire root area of the trees to be moistened, and hence is not very effective. In areas where flat cultivation is practiced in citrus groves, two or three furrows are generally run between the tree rows. With suitable hoe and shovel work in building checks and cross or side furrows, the moisture can be spread uniformly through the root zone of the trees. Merely running water down the furrows without attempting to spread it results in very inefficient irrigation. In sandy or shallow soil overlying lime rock, portable slip-joint pipe is used. A short length of canvas hose is frequently used to connect the portable pipe to the hydrant.

In the irrigation of sugar cane in mineral soil, it is feasible to construct basins and cover them with water to an average depth of 6 or 8 in. Unfortunately the necessary layout can not be cheaply constructed under present conditions. It is believed possible to rearrange sugar-cane plantations so as to provide for quick drainage when needed and also facilitate cheap irrigation; but conditions in the sugar industry are not favorable to the change at this time.

In Florida a considerable acreage is subirrigated. Successful subirrigation requires a porous top soil underlain at a suitable depth by an impervious subsoil. The process of subirrigation requires filling the voids of the surface soil with water to a height which will bring it within range of the plant roots. This process normally requires a much larger quantity of water than other methods of irrigation. Under a considerable part of the flatter sandy lands in Florida is an impervious hardpan stratum at shallow depth, and in certain regions flowing wells furnish ample quantities of water for irrigation at low cost. On some tracts all the irrigation water for a tract is supplied to and distributed by only a boundary ditch, while on others the water is distributed from lines of clay tile closely spaced. Potatoes are grown by the former system and celery by the latter, but all kinds of truck crops are grown by both types of subirrigation.

An interesting and valuable use of spray irrigation in south Florida is for protection against frost damage. It was first used for this purpose many years ago, but only within the past five years has the practice become well established. It now seems evident that the use of spray irrigation on frosty nights is effective to a marked degree in prevently frost damage, under good management and with an ample supply of water. About 70 to 75 gal of water per minute per acre is required for frost protection, which is nearly ten times the capacity needed for irrigation. The greater capacity required for frost protection is due to the fact that water must be applied to the entire area under spray irrigation at one time.

When there is danger of frost, it is good practice to place thermometers at selected spots in the area and to observe the temperatures at frequent intervals, possibly every 20 or 30 min. It is advisable to start the pumps when the temperature is still 3 or 4 deg above freezing and keep them running continually until danger of freezing is past.

I have observed a field of potatoes which came through a freeze practically undamaged while all unirrigated potatoes in the vicinity were a total loss. Within the irrigated field brown spots showed where water from the nozzles had failed to reach and prevent freezing. I also inspected a field of green beans that had been protected by irrigation against a minimum temperature of 22 deg. This field also had brown spots where the water had failed to reach. In addition there was a damaged area where a nozzle had stuck. This nozzle was put in operation again within an hour, but this brief interval was sufficient to cause the loss of the beans under that nozzle. In the instances that have come to my attention, whirling spray nozzles were used; but there seems to be no reason why the overhead pipe system with automatic nozzle line turners should not be equally effective.

The frost protection described above was employed where freezing temperatures prevailed for only a few hours on a single night.

The range of usefulness of this method of protection against frost damage is not as yet well defined, but it seems evident that the following conditions are essential for success.

1. The water supply and the plant capacity must be sufficient to permit the delivery of ample water to all the nozzles simultaneously.

2. Either clean water must be used, or provision must be made to strain out all particles that might clog the nozzles. If the system is old and rust particles are present in the pipes, the lines should be thoroughly flushed before the season of the year when frost protection is likely to be needed.

3. All moving parts in the field equipment, such as whirling nozzles and automatic line turners, should be cleaned and well-lubricated.

[1]Paper prepared for presentation on the program of the Land Reclamation Division at the 26th annual meeting of the American Society of Agricultural Engineers, at Ohio State University, Columbus, June 1932.

[2]Associate drainage engineer, U. S. Department of Agriculture, Bureau of Agricultural Engineering. Mem. A.S.A.E.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

Mineral Oils and Lubrication, W. Kay (Journal of the Society of Chemical Industry [London], 50 (1931), No. 33, pp. 691-696).—The author summarizes data from various sources on the uses and applications of the different grades of lubricating oils and on the choice of lubricants and the making of specifications. Special attention is devoted to the necessary chemical and physical tests for controlling the quality of oil supplies.

The Influence of Irrigation Head and Length of Run on the Use of Water for Alfalfa, D. W. Bloodgood and A. S. Curry (New Mexico Station [State College] Bulletin 197 (1931), pp. 10, fig. 1).—This bulletin reports the results secured over a period of five years from irrigation studies conducted in cooperation with the U.S.D.A. Bureau of Agricultural Engineering on the use of water for alfalfa on Gila clay adobe soil.

The highest average yield per acre-inch was obtained from the 200-ft plat, using a 4-sec ft head of water. The lowest yield was from a 600-ft plat, using a 3-sec ft head of water. The highest average yield per acre-inch per acre, based on length of run, was obtained from the 200-ft series, and the lowest from the 600-ft series. The longer runs were inclined to use the larger amounts of water, although the yields were not affected to any great extent by the variations in the water applied. There was some indication that the shorter plats gave a higher yield per unit of water applied than the longer ones, and there was a tendency for the larger irrigation heads to use larger total seasonal amounts of water.

The size of irrigation head had no important influence on the yields and apparently there was no indication of the existence of a direct relationship between the size of irrigation head and the yield per acre-inch.

Surface Water Supply of Pacific Slope Basins in Oregon and Lower Columbia River Basin, 1929 (U. S. Geological Survey, Water-Supply Paper 694 [1932], pp. VI + 154, fig. 1).—This report, prepared in cooperation with the states of Oregon and Washington, presents the results of measurements of flow made on streams in the Pacific slope basins in Oregon and lower Columbia River Basin during the year ended September 30, 1929.

Apple Store ([Ohio Station [Wooster] County Experiment Farms] Reports 1930, Belmont Co. Farm, pp. 3, 4).—Practical information is given on the planning and construction of an economical and efficient air-cooled apple storage as constructed on the experimental farm. The cost of construction of the storage was about 10 c per bushel capacity.

Public Roads, [March, 1932] (U. S. Department of Agriculture, Public Roads, 13 [1932], No. 1, pp. 20 + [2], figs. 18).—This number of this periodical contains the current status of Federal-aid road construction as of February 29, 1932, programs of estimated state and local highway and bridge expenditures for calendar year 1932, and the following articles: The Western States Traffic Survey, by L. E. Peabody (pp. 1-18); and Truck Great Factor in Farm Freighting (p. 19).

[Agricultural Engineering Investigations at the Ohio Station], H. L. Borst, E. A. Silver, I. P. Blauser, C. O. Reed, R. M. Salter, G. W. McCuen, N. R. Bear, V. L. Overholt, J. S. Cutler, and H. R. Hoyt (Ohio Station [Wooster] Bulletin 497 [1932], pp. 31, 32, 156-166, 169, 170, figs. 8).—Progress results of investigations are reported on corn planter fertilizer attachments; electric recording dynamometer; power requirements of a threshing machine; weed control in soybeans; rate of drying of grain in windrows, shocked, and uncut; combining on side hills; weed control in open drainage ditches; mole drainage; the effect of joint space on the efficiency of tile drains; corn storage; plow draft; and power requirements of grinding red and white varieties of oats.

[Irrigation Investigations at the New Mexico Station] (New Mexico Station [State College] Report 1931, pp. 63-72).—The progress results are presented of investigations conducted in cooperation with the U.S.D.A. Bureau of Agricultural Engineering on duty of water for grapes, cabbage, and onions, on the rate and cause of rise of ground water in the Mesilla Valley, on the irrigation and duty of water for potatoes, on water requirements and the economical use of water for cotton and other crops, on rainfall supplemented by underground water in the production of crops of low water requirements, and on the duty of water for pinto beans.

[Agricultural Engineering Investigations at the South Dakota Station] (South Dakota Station [Brookings] Report 1931, pp. 8-11).—The progress results are presented of studies on the use of the combine harvester-thresher, the development of corn harvesting machinery, and the use of rammed earth for farm building walls.

Disinfection of Wells Containing Bacteria [trans title] P Andre (Gesundheits-Ingenieur [Munich] 54 (1931), No 58, p 574). —A very brief report is presented of the results of experiments which indicate that a lasting disinfection of well water which had been infected from the surrounding soil could be achieved by adding a large quantity of chlorine gas to the well along with sufficient water to raise the surface about 1 m. The water containing chlorine is thus forced into the surrounding ground. It may be necessary to waste some of the water, but if the well can be left out of use for a sufficient period of time the disinfected water is free from taste. The effect was found to last several months.

Harvesting Field Peas with the Combine, H Beresford and E N Humphrey (Idaho Agricultural College [Moscow] Extension Bulletin 85 [1932], pp 16, figs 15).—The results of field experiments on the harvesting of field peas with the combine are presented, together with practical information on the process. It was found that there was considerable shattering of the peas before the fields were entered with the harvesting machinery. By the semistationary combine method an average harvested yield of 1,350 lb per acre was obtained in a 46-a field of peas with a loss of 333 lb per acre. In a 55-a field, which was harvested by the stationary thresher method, 1,104 lb of harvested peas were obtained per acre with a loss of 895 lb per acre. The average for 1,198 a of peas harvested by the direct combine method showed a yield of 1,129.51 lb of harvested peas per acre, with an average harvest loss of 438.7 lb per acre.

Refrigeration in the Handling, Processing, and Storing of Milk and Milk Products, J T Bowen (U S Department of Agriculture, Miscellaneous Publications 138 [1932], pp 59, figs 32).—This publication discusses the various applications of refrigeration in the operation of modern dairy plants and the methods most commonly used in the latest and best-equipped plants. It is prepared for the information of those engaged in the dairy industry and for manufacturers of refrigerating machinery. It contains sections on mechanical refrigeration, insulation, methods of utilizing refrigeration, physical properties of milk and milk products in relation to cooling, relation of temperature to bacterial and chemical changes in milk, seasonal variation in milk production, uses of refrigeration in the dairy industry, ice cream plants, solid carbon dioxide, and brine ice.

Drainage of Land Overlying an Artesian Basin, O W Israelsen (Utah Academy of Science [Salt Lake City] Proceedings, 8 [1930-1931], pp 35-37).—In a contribution from the Utah Experiment Station, the organization of studies of the drainage and reclamation of certain lands overlying an artesian basin, which are being conducted in cooperation with the U S D A Bureau of Agricultural Engineering is described. Data from pumping are briefly reported showing a substantial influence of pumping on water pressures. It also was found that the water pumped to provide drainage may be used advantageously for irrigation, thus reducing the costs directly chargeable to drainage.

Book Review

"Irrigation Principles and Practices," by Orson W Israelsen (Mem A S A E), professor of irrigation and drainage, Utah State Agricultural College, is the latest addition to the Wiley Agricultural Engineering Series. The chapter headings include Sources and Conveyance of Irrigation Water, Measurement of Irrigation Water, Pumping Water for Irrigation, Irrigation Methods, Farm Irrigation Implements and Structures, Some Properties of Soils, Basic Soil and Water Relations, Storage of Water in Soils, The Movement of Water in Soils, Irrigation and Alkali, Transpiration and Evaporation, Time of Irrigation Consumptive Use of Water in Irrigation, Relation of Crop Yield to Water Consumed, Social and Administrative Aspects of Irrigation, Amounts of Water Used in Irrigation, Efficiency and Alfalfa, Irrigation of Sugar Beets and Potatoes, Irrigation of Orchards, Irrigation in Humid Climates, and General Problems of Irrigation. The author's major objective in the preparation of this volume has been to meet the needs of college and university students who seek information concerning the aspects of irrigation which are not included in works on irrigation engineering. These aspects of irrigation, which are sometimes referred to as the agricultural phases, are of special interest to students of agriculture and of agricultural engineering. The book includes an appendix devoted to problems and questions designed especially for the student. Cloth, 6x9 inches, 420 pages, 174 figures indexed. Published by John Wiley & Sons, Inc, New York, N Y. List price, $5.00 net.

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Raymond Olney, Editor

R. A. Palmer, Associate Editor

Experiments in Farming

FROM TIME TO TIME we have taken occasion to pay our editorial respects to pioneering studies in what we have considered an otherwise neglected field of agricultural-engineering opportunity—the study and application of engineering principles to the use of individually efficient equipment items in a manner to increase overall farm efficiency and profit.

Pertinent articles in our recent issues include McKibben and Aglibut's analysis of the economics of tractor-engine operation in relation to load and other considerations of common farm operating conditions[1]; Randolph's studies of labor requirements, hours of daylight, rainfall, fertilization, plant spacing, and yields in cotton production in the Southeast, in relation to possibilities for increased production efficiency[2]; McAlister's report on farm machinery demonstrations designed to encourage individual farmers to take their next logical step in lowering their production costs[3]; and the latest of White's analyses of farm chore efficiency as influenced by building design and location[4].

In this issue we are pleased to parallel Wilson's viewpoint[5], as an engineering-minded economist, of the need of further effort to increase farm net or overall efficiency, with Duffee's progress report of the Wisconsin project[6], applying detailed, extensive, engineering farm planning in the manner which Wilson suggests.

Wilson has implied that new knowledge is not "applicable to agricultural production without changes in technology, engineering, or the habits, customs, or folk-ways of the farmers themselves." In this, we believe, he has given expression to a basic principle supporting the applicatory type of agricultural-engineering research which we have commended. It is a solid foundation for his further stimulating reasoning that "Agriculture is going to be engineered . . . . . Biological research, engineering research, invention and design have within them potentialities which will express themselves in a far more revolutionary way in the future than in the past . . . . . This engineering attitude of looking at the jobs of farm production, analyzing them, reorganizing them and redesigning them, is now having and will continue to have, a profound influence on agriculture . . . . . This engineering approach is going to be generally applied to agriculture in the future, but the job analysis and redesigning of plant and equipment will proceed only as fast as our habits and customs will allow us to make the necessary psychological, social and economic adjustments . . . . . Scientific and mechanical advance have produced new problems which have to be met by new attitudes of mind and new social and economic control . . . . As new machines and new processes are developed we can assume that they will either adjust themselves to the prevailing organization, size and type of farm, or the farm organization and size will be adjusted to the new techniques and equipment . . . . . Effort to further this adjustment . . . . . requires setting up experiments on farms; not experimental farms, but experiments in farming . . . . . This line of experimentation would begin by engineers and economists making a thorough engineering and economic analysis of a particular kind of farming. Then . . . . . they might work out and experiment on a new kind of farm plan which would take advantage of the best biological science, engineering technique, and economic organization."

The Wisconsin project seems to have anticipated Wilson's appeal for experiments in farming. It is based on a similar philosophy. In Duffee's words . . . . "we must look to different and better methods of farming, out of which to make farm profits . . . . . Our implement companies, aided to some extent by our agricultural experiment stations, have developed what today seem to be wonderfully compact, efficient, durable machines of wide adaptability . . . . . But the complicated management problem involved in the adoption of this equipment has been almost wholly neglected from a research point of view."

After an analysis of dairy farming in Wisconsin, Duffee and his cooperators, in the "large farm" part of the project, on two individual farms, have surveyed, mapped, inventoried, and kept complete financial and operation time records. They have discarded some machinery and added new as needed to adapt the equipment to the farms. They have also adapted the farms to the equipment by increasing acreage and herd size, eliminating and resetting fences, and improving field size and shape. Incidentally the power and machinery investment per acre has been substantially lowered, the crop acreage per drawbar horsepower increased and the crop acreage handled per man almost doubled.

These early results only suggest the increased efficiencies which may be expected in both the large and small-farm phases of the project by "proper use and coordination of this equipment to the entire farm business . . . . ."

A fair measure of the worth of projects of this type would include several direct and indirect values. The benefit to the project farms and cooperating farmers is apparent. So are the projects' values as demonstrations to other farmers operating under similar conditions. As forerunners of progress in the application of engineering to agriculture they will give direction not only to the efforts of other farmers, but to the further development of farm equipment and processes, and to the biological, physical and social foundation sciences of agriculture. Studied attempts to correlate and apply on specific farms "the best biological science, engineering technique, and economic organization" may be expected to reveal for further study by the sciences concerned, any points of weakness in the network of knowledge supporting sound, substantial social and economic progress in agriculture.

Indirect benefits need scarcely be mentioned except to point out that these "experiments in farming" are also experiments in one phase of social and economic planning, the growing need of which is noted by both Wilson and Duffee.

[1] "Some Factors Affecting the Economic Use of Tractor Engines at Part Loads," by E G McKibben and A P Aglibut. Vol 13, No 3, AGRICULTURAL ENGINEERING (March 1932), p 73.

[2] "Use of Machinery in Cotton Production," by John W Randolph. Vol 13, No 4, AGRICULTURAL ENGINEERING (April 1932), p 99.

[3] "An Extension Program in Farm Machinery," by J T McAlister. Vol 13, No 4, AGRICULTURAL ENGINEERING (April 1932), p 104.

[4] "Farmstead Arrangement and Its Effect on Operating Cost," by H. B. White, Vol 13, No 8, AGRICULTURAL ENGINEERING (August 1932), p 217.

[5] "Economic Aspects of an Engineered Agriculture," by M L Wilson.

[6] "A Planned Engineered Agriculture," by F W Duffee.

A.S.A.E. and Related Activities

North Atlantic Section to Meet at Albany

THE North Atlantic Section of the American Society of Agricultural Engineers will hold its usual yearly meeting on October 27, 28, and 29, at Albany, N. Y.

One of the innovations of this meeting is the selection by the section chairman of a different member of the Society to preside at each session, the selection being based on the interest of the member selected in the program of the session. R. W. Trullinger, a past-president of the Society, and senior agricultural engineer, U.S.D.A. Office of Experiment Stations, will preside at the forenoon session on Thursday, October 27. Following a welcome by the mayor of Albany, will be the address of the Chairman of the North Atlantic Section, B. B. Robb, agricultural engineer, Cornell University. Following Mr. Robb will be presented a paper, entitled "Agricultural Engineering in High Schools," by W. J. Weaver. The session will be concluded with a paper on hay chopping and storing by F. J. Bullock and F. H. Hamlin, vice-president and advertising manager, respectively, of the Papec Machine Company, the discussion of which will be led by R. U. Blasingame, agricultural engineer, Pennsylvania State College.

The afternoon session will be presided over by H. W. Riley, a past-president and charter member of the Society and head of the agricultural engineering department at Cornell University. The session will open with a symposium on modernizing the farm for convenience, comfort, and time saving, which will include discussions on the kitchen and home by Miss Eloise Davison of the National Electric Light Association; on yard and outbuildings by J. F. Ham; on rural architecture by M. J. Markuson, Massachusetts Agricultural College. The discussion of the symposium will be led by L. G. Heimpel of Macdonald College.

This session will be featured also by a symposium on spraying, contributions to which will include a discussion on portable sprayers by Paul Judson; on stationary sprayers by E. R. Gross, Rutgers University, and on dusting vs. spraying by E. W. Mitchell.

The session will be concluded by a paper, entitled "Milking Parlors and Equipment," by J. L. Strahan, consulting agricultural engineer.

The evening of October 27 will be devoted to round table discussions (1) for the rural electric group, with Geo. W. Kable presiding; (2) for the farm structures group, with M. C. Betts presiding; and (3) for the farm machinery group, with R. H. Smith presiding.

The forenoon session of Friday, October 28, will be presided over by R. W. Carpenter, a past-chairman of the Section and head of the department of agricultural engineering at University of Maryland, a feature of which will be a symposium on soil heating, including a discussion of greenhouses and propagating benches by Paul Dempsey, and on plant houses and sterilizers. This will be followed by a paper, entitled "Engineering Economics," by Dr. V. B. Hart, agricultural economist, Cornell University. The session will be concluded by a paper on the curing of farm crops by G. N. Harper of the Virginia Electric & Power Company.

The afternoon of Friday, October 29, will be devoted to a visit to the port of Albany, and to the inspection of farms in the vicinity of Albany specializing in the utilization of electricity, which will be in charge of D. E. Blandy, chairman of the local arrangements committee.

The banquet, which is one of the principal events of this section meeting, will be held on the evening of October 28, a feature of which will be an address on the agricultural engineer's place in modern industry by the President of the Society, Charles E. Seitz, head of the department of agricultural engineering, Virginia Polytechnic Institute. Another address of the evening will be on the subject "The Engineer's Job in Agriculture," by Peter T. Ten Eyck. The speechmaking will be followed by the usual business session of the Section.

The meeting will conclude with a half-day session on Saturday forenoon, October 29, with W. H. McPheters, agricultural engineer, Connecticut Agricultural College, presiding. This session will be featured by a paper on ventilation problems by A. M. Goodman, agricultural engineer, Cornell University, the discussion of which will be led by L. G. Heimpel of Macdonald College. The second paper on the program deals with the subject of brooders and brooder houses and will be presented by N. D. Herrick, with R. W. Carpenter, University of Maryland, leading the discussion. The program will be concluded with an address by John M. McKee on the accomplishments in rural electrification, with R. F. Buckman leading the discussion.

ASAE Meetings

North Atlantic Section — Albany, New York, October 27, 28, and 29, 1932.

Power and Machinery Division — The Stevens, Chicago, Illinois, November 28, 29, and 30, 1932.

Structures Division — The Stevens, Chicago, Illinois, November 28 and 29, 1932.

Southern Section—New Orleans, Louisiana, February 1, 2, and 3, 1933.

The Power and Machinery Division Program

THE Power and Machinery Division of the American Society of Agricultural Engineers will hold its usual fall meeting at Chicago during the week of the livestock show. The dates are November 28, 29, and 30, and the place of the meeting will be The Stevens, where the Division has met the past two years.

The program announced by Division Chairman W. Leland Zink is well under way. The program is still in the tentative stage, and while main topics are being announced, the announcement as to speakers is limited to those who have accepted the invitation of the chairman to appear on the program.

The opening session on Monday, November 28, will feature subjects on artificial forage crop drying and hay making by natural curing means. The subject of artificial drying will include a paper on power, labor, and fuel requirements, and one on the nutrient value of artificially dryed forage; and under the heading of making hay by natural curing will be a paper on recent developments in hay harvesting and processing machinery.

The afternoon program of the same day will be known as a harvesting session, the first paper on this program dealing with the subject of combine specifications by I. D. Mayer, agricultural engineer, Purdue University. As a part of the discussion of this paper, R. B. Gray, chief of the division of mechanical equipment in the U.S.D.A. Bureau of Agriculture, will discuss the problems of combining soybeans in the South, and J. K. MacKenzie, agricultural engineer of the Caterpillar Tractor Company, will describe the barge method combine harvesting employed in the spring wheat area. Another feature of the program of this session is a paper, entitled "Observations from Corn Picker Studies," by C. K. Shedd, agricultural engineer, U.S.D.A. Bureau of Agricultural Engineering. Contributors to the discussion of this paper will include engineers from the farm equipment industry and agricultural engineers from the state colleges of the principal corn-producing states. At this session also R. U. Blasingame, agricultural engineer, Pennsylvania State College, will present a report of a recent study of the performance of the Ronning ensilage machine.

Either the forenoon or afternoon session of November 28 will also feature a paper reporting a recent study of the testing of threshing machines with the new Ohio dynamometer, to be presented by G. W. McCuen, head of the department of agricultural engineering, Ohio State University.

The evening of Monday, November 28, will be given over to such group conferences as committees or groups may desire to hold at the time of the meeting.

The entire forenoon session of Tuesday, November 29, will be known as an economics session, the principal feature of which is a scheduled paper on the subject "Some Economic Aspects of Farm Mechanization," by Arnold P. Yerkes of the International Harvester Company. Prepared discussions of this paper will be presented by Harper Sibley, manager of the Sibley Farms, D. Howard Doane and C. H. Everett of the Doane Agricultural Service, and Leonard J. Fletcher, agricultural engineer, Caterpillar Tractor Company.

At the afternoon session E. V. Collins, agricultural engineer, Iowa Agricultural Experiment Station, will present a paper, entitled "Efficiency Tests of Tractor Wheels and Tracks," reporting recent studies by him on that subject, and along the same general line will be a paper on the subject of "Rubber Wheel and Track Equipment for Tractors," to the discussion of which engineers of the rubber manufacturers and tractor engineers will be invited to contribute. Also an interesting paper on tractor valve problems and recent developments in valves is being scheduled for this session.

An extra day has been added this year to the usual two-day meeting of the Division, which will be given over exclusively to a round table discussion of the general-purpose farm tractor. It is planned that the session will open with a general paper on the subject by one of the leading engineers of the tractor industry and that other leading tractor engineers will be invited to contribute to the discussion. A feature of the session will be reports by agricultural engineers from various state colleges at which a special study has been made of the specific requirements for the general-purpose tractor. It is planned that the principal papers and prepared discussions will require a minimum of time, leaving almost the entire day to a general discussion by all interested in the various problems confronting engineers relative to the general-purpose tractor.

Structures Division to Present Program

THE Structures Division of the American Society of Agricultural Engineers has announced through its chairman, Henry Giese, that it will present its usual mid-year technical meeting at The Stevens, Chicago, November 28 and 29, paralleling the meeting of the Power and Machinery Division.

The program will feature four main topics or symposiums devoted to the most pressing problems confronting the agricultural engineers of the farm structures group at the present time.

The first session on Monday forenoon, November 28, will start with a symposium on the subject of dairy housing, the principal feature of which will be a paper by M. A. R. Kelley, agricultural engineer, U.S.D.A. Bureau of Agricultural Engineering, presenting the results of recent studies he has made on this subject in Wisconsin. The entire session will be devoted to the subject of dairy structures and housing.

The afternoon session of the same day will be devoted exclusively to discussions on the general topic of the economics of farm buildings, the principal speaker being J. C. Wooley, head of the agricultural engineering department, University of Missouri, who has devoted extensive study to this subject.

A special opportunity will be provided for committees and other groups, who care to do so, to hold round table sessions during the evening of Monday, November 28.

The forenoon session of Tuesday, November 29, is to be devoted exclusively to the subject of building materials. One of the principal subjects for discussion at this session will be on the treatment of silo walls. Other subjects will include the development and application of metallic zinc paint and a paper on the general subject of roofing nails.

The afternoon session of November 29 will be given over to a general discussion of farm building plan services, a subject that has been prominently before the structures group recently. W. G. Ward, agricultural engineer, Kansas State College, will lead the discussion of this subject.

Necrology

HUGH ARBUTHNOT BROWN, director of reclamation economics, Bureau of Reclamation, U S Department of the Interior, passed away suddenly August 13. He had been a member of the American Society of Agricultural Engineers for just one year.

Doctor Brown was born at Ann Arbor, Michigan, in 1877. He was a graduate of both George Washington University and Princeton University. He had been connected with the Department of the Interior since 1907, first as private secretary to Secretary James R. Garfield, and later with the Reclamation Service. For a time he was private secretary to Director of the Census E. Dana Durand, but in 1921 he returned to the Reclamation Service, where he was continuously employed until his passing. He rose rapidly in the service, from one grade to another, and in 1929 he became director of reclamation economics, succeeding Mr. George C. Kreutzer, deceased.

In 1930 he was detailed to the President's Commission on the Conservation and Administration of the Public Domain, serving more than a year as executive secretary.

RAY AUSTIN GRAHAM, secretary-treasurer, Graham-Paige Motors Corporation, was drowned at Chatam, Ontario, on August 13. He had been a member of the American Society of Agricultural Engineers since 1912.

He was born at Washington, Ind., in 1889. In 1908 he was graduated with a bachelor of science degree from the University of Illinois. He then took over the management of the Graham farm properties, near his birthplace, in connection with the operation of which he became interested in the commercial development of the farm tractor, an interest which was sustained throughout his lifetime.

Mr. Graham and his brothers, Joseph B. and Robert C., later engaged in the manufacture of the Graham Bros. motor truck, one of the outstanding trucks in its time. In 1925 the Graham truck became a unit of Dodge Brothers, and the three Graham brothers became executives in the Dodge organization. They later disposed of their interest therein, and acquired the Paige-Detroit Motor Car Company. In 1927 the Graham-Paige Motors Corporation of Detroit was organized with Ray A. Graham as secretary-treasurer, an office which he held until his passing.

New ASAE Members

Walter B. Alford, agricultural representative, E. I. Du Pont de Nemours, (Mail) P. O. Box 580, Gulfport, Miss.

Enrique Burgos, manager "La Hormiga," San Clemente, Chile, South America.

Henry P. Fritsch, secretary-treasurer, Vane-Calvert Paint Co., 1601 N. Broadway, St. Louis, Mo.

Jim S. Hamilton, rural electrification engineer, Virginia Electric & Power Co., Richmond, Va.

Herbert S. Riesbol, junior civil engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. (Mail) Box 694, Guthrie, Okla.

Robert B. Withrow, research assistant, horticulture department, Purdue University, Lafayette, Ind.

Transfer of Grade

Lawrence H. Schoenleber, instructor in agricultural engineering, University of Minnesota, University Farm, St. Paul, Minn. (Junior to Associate Member)

Applicants for Membership

M. A. Jones, graduate laboratory assistant, agricultural engineering department, Alabama Polytechnic Institute, Auburn, Ala. (Mail) Box 781.

J. W. Shields, field engineer, Firestone Tire & Rubber Co., Akron, Ohio. (Mail) 213 Crescent Drive.